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Article

Investigating the changing land use patterns and their impacts on ecosystem in the Teesta River Basin

Md. Mizanur Rahman

Department of Environment and Development Studies, United International University, Dhaka 1212, Bangladesh; mizanur@eds.uiu.ac.bd

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Abstract: This study investigated the changing land use patterns and their impacts on ecosystem in the Teesta River Basin of northwestern Bangladesh. Although anthropocentric land use patterns, including agricultural land use, settlements, built areas, and waterbody loss, have been increasing in the Nilphamari district, by negatively affecting local ecosystems, they have not been identified by prior research. Limitations of contemporary literature motivated me to work on this crucial ground in the Teesta River Basin in Northwestern Bangladesh. This study applied a mixed research approach to identify the study objectives. Firstly, the land use and land cover (LULC) changes which occurred between 2000 and 2020 were detected using satellite imagery and supervised classification method. In addition to the detection of LULC changes, the study explored the people's perceptions and experiences about the ecosystem changes resulted from the LULC changes over the last 20 years, conducting stakeholders' consultations and household surveys utilizing a semi-structured questionnaire. The findings indicated that waterbodies in Nilphamari district have significantly decreased from 378 km^2 in 2000 to 181 km^2 in 2020. In the same way, the vegetation coverage has reduced 187 km^2 between the years 2000 and 2020. On the contrary, agricultural lands (croplands) have increased from 595 km^2 to 905 km^2 and settlements have increased from 81 km^2 to 206 km^2 between the years 2000 and 2020. From the chi-square test, it was found a significant association between ecosystem change and biodiversity loss. It was further identified that waterbody decreases have significant impacts on aquatic ecosystems. The results of this study also indicated that due to the introduction of foreign tree species, local and native species have been significantly decreasing over the time. This study emphasizes the non-anthropocentric and inclusive land use policy implications for protecting life on land and preserving the aquatic ecosystem in Bangladesh.

Keywords: land use; ecosystems; native tree species; biodiversity; Nilphamari

1. Introduction

Ecosystems are functional units that involve interactions between organisms and their physical environment (Enger and Smith, 2015; Singh, 2024). It refers to the areas in which a variety of living organisms interact mutually with their living and nonliving counterparts. Ecosystem covers its population, resources, and environment, along with their positions, functions, and roles (Long et al., 2009; Meng et al., 2018). Between living and non-living components of the ecosystem, land is considered one of the major constituents of non-living components. Land, itself is a system, which refers to the persistent interactions between human societies and terrestrial ecosystems. Land use is well-regarded as a major anthropogenic action which reshaped the surface of the earth, resulted in changing the ecological functions of the planet (Ellis, 2021). Land use management of a territory aims to achieve specified outcomes that influence the natural features of the lands (Fu et al., 2015).

Today, most of the countries of the world have been significantly modified by human activities. The change of the land use is the key factor resulted from changing human activities causing a transformation of the natural environment by transforming land surface, species compositions and biogeochemical cycles of the planet (Chapin et al., 2011; Mendoza et al., 2011). Historical record says prior to the invention of agriculture; terrestrial landscapes were natural and later after its invention anthropogenic land use modified the natural environmental arrangements of the earth surface particularly for farming. Even during the first colonial epoch, as mentioned by Enger and Smith (2015), only small portions of the natural landscape were converted to farming, manufacturing, and housing. As a result of increasing population, more and more lands were changed to agriculture, and settlements and building urban centers. In the last century, the earth has observed a significant transition of its land surface and around three-quarters of the Earth's land surface has been changed by human beings for meeting their own purposes (Winkler et al., 2021). The large-scale anthropogenic effects on the earth surface dominantly began after the industrial revolution (Chapin et al., 2011; Moran, 2016; Scott, 2020).

Current land use alterations clearly reduce ecosystem's capacity to endure their productivity in the long run, from the local to the global scales (Foley et al., 2005). It is recognized that the transformation of land use has severe impacts for global and local climates, the worldwide biogeochemical cycles such as carbon, nitrogen, and water, and biodiversity (Goldewijk and Ramankutty, 2024). Moreover, land use is thought as a dominant factor leading to the risk of desertification (Wijitkosum, 2016).

In relations to the land use change, thousands of studies have been conducted in the diverse regions of the world (Alele and Harold, 2024; Hasan et al., 2020; Koo et al., 2024; Kong, 2022; Tripathi et al., 2021). These studies revealed a significant transformation in the LULC changes over the years and their implications.

Bangladesh has been experiencing drastic land use transformation because of various stresses along with the burden of excessive population like the other parts of the world. Every year, nearly 82,900 ha of cropland and 221 hectares of arable land are transformed into other land uses in order to meet dynamic social demands (Akber et al., 2018; Islam et al., 2011). Numerous studies have identified that the LULC have been significantly changed over the years in the diverse areas of Bangladesh. Such as, Akber et al. (2018) identified the decreasing trends of agricultural land and deforestation. Likewise, Hoque et al. (2020) revealed that farming and mangrove forest lands experienced a significant decrease, while rural and urban settlements are at the greatest upsurges in coastal Bangladesh. Both studies (Akber et al., 2018; Hoque et al., 2020) assessed the impacts of these land use changes on the ecosystem services over the time. The current studies in Bangladesh failed to provide comprehensive overviews on how the LULC changes have been affecting ecosystems, including local biodiversity, local (native) plant species, local bird species and aquatic ecosystems. They also could not reflect how increasing agricultural land use affects the local ecosystems taking people's perception into consideration. Moreover, considering Nilphamari district, located in northwestern Bangladesh, as a case, no study has been done as of today on the impacts of LULC changes on local ecosystems. Although Rahman et al. (2023) attempted to identify the relationship between urban land use

changes and their impacts on local people's livelihoods in Nilphamari sadar upazila (a sub-district of Nilphamari), they have not extended their findings on ecosystems. The limitations of the existing studies worked as a motivating factor to explore the LULC changes of Nilphamari District and to investigate their impacts on the local ecosystems from people's perspectives. This study followed a mixed research approach to explore LULC changes over the last two decades and determine their consequences on local ecosystems. Primarily, this study identified the land use and land cover changes that occurred between 2000 and 2020 using satellite imagery and the supervised classification method. People's perceptions and experiences on land use and land cover changes and their impacts on the ecosystems were gathered by applying stakeholders' consultations and household surveys between November 2021 and October 2023.

The government of Bangladesh aims to attain sustainable development goals to be achieved with an especial focus on the life on lands (SGD 15) which also reflected in the 8th 5-year plans. Currently country's 15 percent lands are covered by forests and it aims to reach at 20 percent by 2030. Again, Bangladesh also hopes to increase fresh waterbody and freshwater biodiversity from 3 in 2018 to 5 percent by the year 2030 (MoP, 2020). To achieve the SDG 15 and its associated targets by 2030, proper land use plans and land management are necessary. This study suggests inclusive and non-anthropocentric policy implications, including protection of biological diversity and preserving the water body and its ecosystems, for agricultural land management and human settlement development.

2. Materials and methods

2.1. Study area

This study was conducted in Nilphamari District, situated in the Teesta River Basin of northwestern of Bangladesh. This district covers area 1546.59 km^2, located in between 25°44′ N and 26°19′ N latitudes and in between 88°44′ E and 89°12′ E longitudes (see **Figure 1**). It is bordered by Lalmonirhat district on the east, Panchagarh and Dinajpur districts on the west, Rangpur district on the south, India (West Bengal) on the north (Banglapedia, 2024).

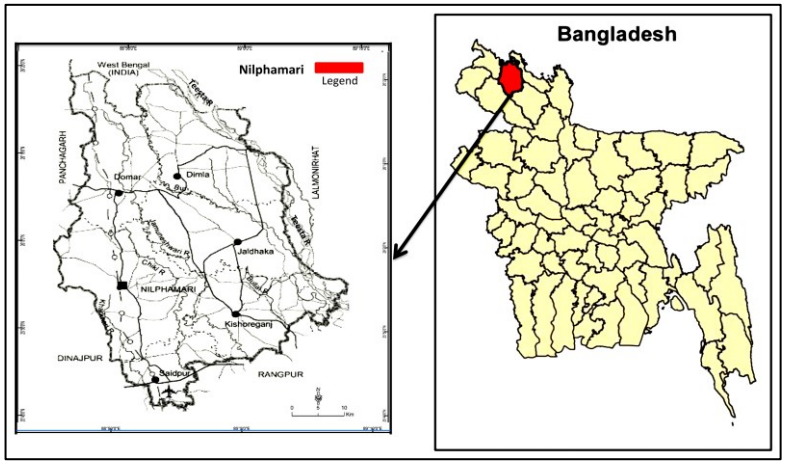

Figure 1. Locational map of Nilphamari district in Bangladesh.

Historically the economy of Nilphamari district is predominated by agriculture and most of the people in this district directly or indirectly depend on agriculture and related activities (BBS, 2013). Nevertheless, industrial development is noticeable in Nilphamari after the establishment of Uttara Export Processing Zone (EPZ) by the government in 2001 (Rahman et al., 2023).

The district experiences yearly average temperatures ranging from 32.3°C to 11.2°C, with an average rainfall of 2931 mm. The major rivers of this district include Teesta, Jamuneshwari, Chikni and Dhaigan (BBS, 2013).

2.2. Primary data collection

Primary data were collected by employing mixed research method; which refers to the utilization of both qualitative and quantitative data collection techniques in a single research (Alexander et al., 2001; Knappertsbusch et al., 2021; Rahman et al., 2023) to explore the people's perceptions about the impacts of LULC change on the ecosystems. In order to meet the study objectives, stakeholders' consultations primarily have been conducted among 60 respondents from four different areas of three upazila, including Jaldhaka, Dimla and Nilphamari Sadar. The target of the stakeholders' consultation is to gain preliminary understanding about the ecosystem changes in Nilphamari district and to develop the thematic areas of the questionnaire for household surveys. After the development of questionnaire, a household survey was done among 394 respondents from the four locations of three different upazila namely Jaldhaka (n = 240), Dimla (n = 70), and Nilphamari Sadar (n = 84) in Nilphamari District. The respondents of the household survey were randomly chosen based on their age group and all the respondents were aged above 35 years. Above 35 years aged people were chosen because they were well-aware about the diversity and dimensions of the changes in happened in the ecosystem in their locality.

Data were collected employing three research assistants from November 2021 to October 2023 using semi-structured questionnaire for the better comprehensions of the practical aspects of my research. Quantitative data were processed and analyzed by using statistical software STATA. Like prior studies (Alam et al., 2022; Rahman et al., 2023), this study was conducted following a standard ethical protocol. All the respondents were aware of the study objectives and they were ascertained about their data confidentiality. After receiving both verbal and written consents form the respondents, the research assistants started interviews. After the end of data analysis, the findings were verified by the respondents in a group.

2.3. Land Use and Land Cover (LULC) changes analysis

To detect the land use and land cover changes of Nilphamari district, this study used satellite image employing supervised classification with forest classifier algorithm like the other studies (Din and Yamamoto, 2024; Rahman et al., 2023) on Google Earth Engine. This method was utilized because of its suitability, wide-scale reliability and accuracy, and flexibility to detect the land use changes. LULC changes was observed using satellite imagery and the supervised classification method on a 10-year interval based on three specific years, including 2000, 2010 and 2020 using monthly composite images.

The Harmonized Sentinel-2 MSI: Multispectral Instrument, Level-2A dataset for 2020 was utilized. Sentinel-2 is a multispectral imaging mission with excellent resolution that is commonly utilized for land monitoring studies (soil, waterbodies, vegetation cover, etc.). Sentinel-2 has an imaging resolution of 10 m. The USGS Landsat 5 TM Collection 2 Tier 1 Raw Scenes file has been utilized for the years 2000 and 2010. This dataset has a resolution of 30 meters. For the detection of the LULC changes, ArcGIS 10.8 was used.

The LULC categories employed in this study are listed in **Table 1** along with their attributes.

Table 1. Descriptions of the land use classification.

Land use type	Descriptions
Settlement	Residential, Commercial and industrial and other built areas
Croplands	Agricultural area, Farming lands, and crop fields
Vegetation	Forest, trees, palms, scrub and others
Water bodies	River, lakes, ponds and other reservoirs
Barrenlands	Land which has extremely few flora and no trees

Source: adopted from Rahman et al., 2023; Dewan and Yamaguchi, 2008.

2.4. Data analysis

Quantitative data mostly include household demographic data and people's perception about the consequences of land use/land cover changes, while qualitative data include stakeholders' consultations, which were done for identifying people's experiences of LULC change in their locality. This also aimed to develop the thematic areas of the development of questionnaire for household surveys. The data of this study were analyzed using statistical software Stata, particularly for measuring frequencies, percentage, and Pearson's Chi-square test for statistical significance. LULC changes classification was performed using the random forest classifier method on the Google Earth Engine (GEE) platform, while for LULC changes analysis and map representation, we used ArcGIS 10.8 GIS software.

3. Results

3.1. LULC Classification of Nilphamari District

In 2000, the land use and land cover was majored by vegetation and farmland. About 449 km^2, or 28 percent of the total area, were covered by vegetation, whereas 595 km^2, or 37 percent of the area, were used for farmland. A total of 378 km^2 (23.79 percent) of the land area was covered by water bodies (ponds, rivers, and other wetlands); domestic vegetation primarily covers the settlement areas; and around 81 km^2 (5 percent) are made up of built-up area. The 2000 Nilphamari district had a sizable quantity of barren land; almost 86 km^2, or 5.41 percent, of the total land area (see **Figures 2** and **3**). Charred and accreted ground make up the majority of these desolate locations.

In 2010, the Cropland area was still dominated land use of the district (714 km^2—44.93 percent), the water bodies were the second highest land use in the district, 360

km^2 (22.66 percent), vegetation cover decreased significantly in 2010, which was 289 km^2 (18.18 percent). The settlements have increased by 2000, about 187 km^2 (11.76 percent). On the other hand, barren land has decreased in the area (39 km^2—2.45 percent) (see **Figures 2** and **3**).

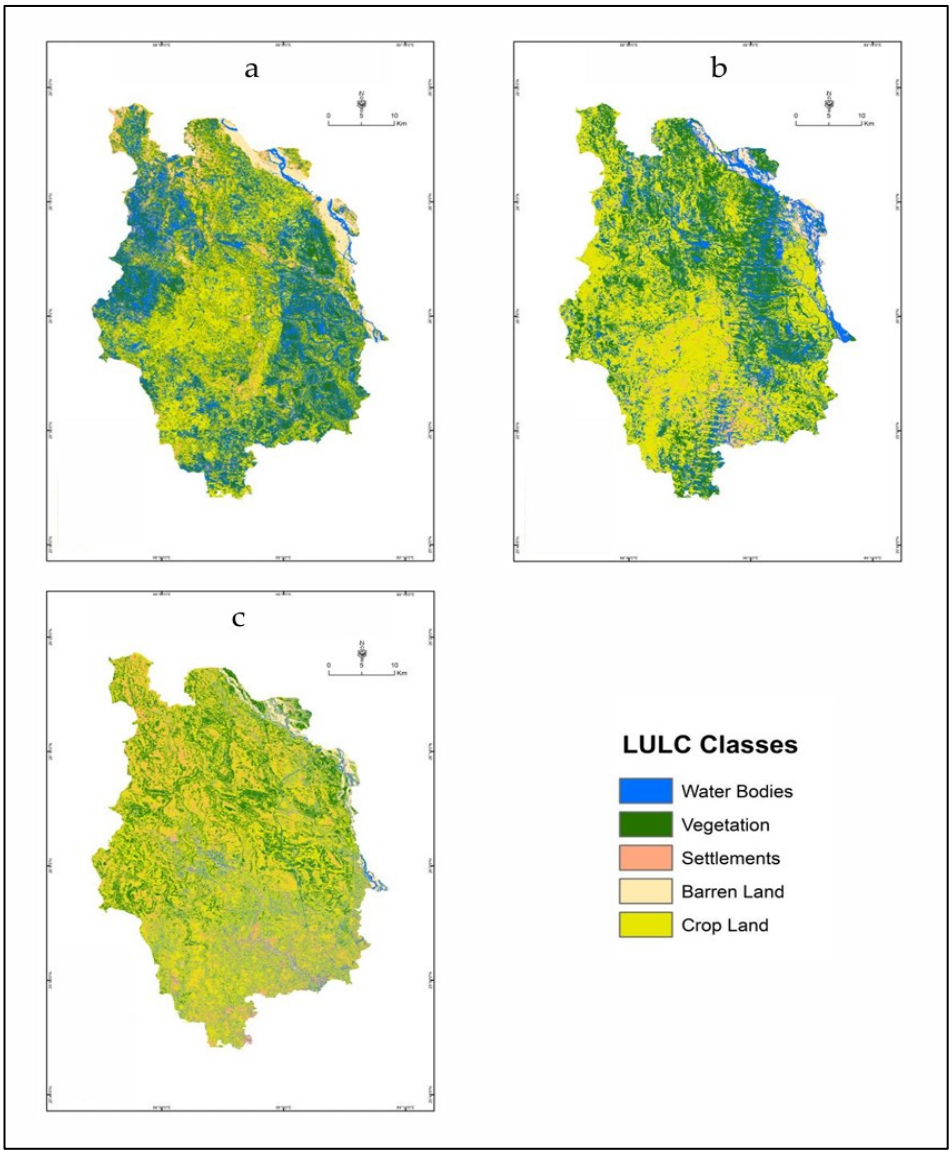

Figure 2. LULC map of Nilphamari District from 2000 to 2020: **(a)** 2000; **(b)** 2010; **(c)** 2020.

Over the years from 2000, the vegetation cover and water bodies have decreased significantly. The croplands, on the contrary, increased over the years. In 2000, the croplands were 37 percent of the overall area. In 2010 it increased to 714 km^2, and in 2020 it increased to 905 km^2, 57 percent of the total area. Settlements or built-up areas increased in the area over the last 20 years. In 2000, 5 percent of the total area was a settlement; in 2010, it increased to 11.76 percent, and in 2020, it grew to 12.96 percent. The amount of barren land has decreased over the years (see **Figures 2** and **3**).

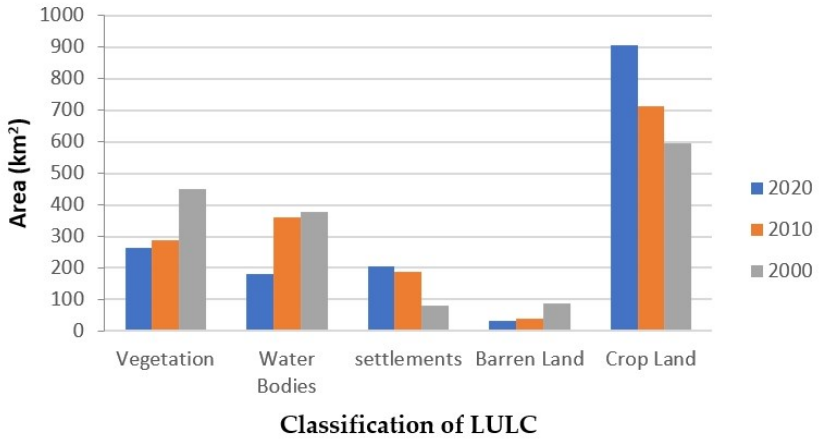

Figure 3. LULC classes by area in 2000, 2010 and 2020 respectively.

3.2. Socio economic status of the respondents

A total of 394 household surveys were conducted in the four different locations of Nilphamari Sadar, Jaldhaka and Dimla upazila where 58.38 percent respondents were men and 41.62 percent were women. **Table 2** shows that considering the educational background, approximately 36 percent respondents hold educational status up to grade 5 and 32 percent respondents belongs to the educational categories between grade 6 and grade 12 whereas only 3.3 percent respondents have education graduation and above. On the other hand, 28.68 percent respondents do not have any formal education.

Table 2. Socio-economic characteristics of the respondents.

Variable	Category	Frequency	Percentage (%)
Gender	Man	230	58.38
	Woman	164	41.62
Education	No Education	113	28.68
	Grade 1 to 5	142	36.04
	Grade 6 to 12	126	31.98
	Graduate and above	13	3.3
Occupation	Farming/Agriculture	160	40.61
	Business	108	27.41
	Day laborer and other	30	7.61
	Housewife	65	16.5
	Service sector	18	4.57
	Unemployed	13	3.3

Table 2 also indicates that most of the respondents of this study are in farming (40.61 percent), whereas business occupied 27.41 percent respondents. Most of the women respondents of this study are housewives. The age range of the respondents varies between 35 to 72 years.

3.3. Household land use patterns of the respondents in 2000, 2010 and 2020

Table 3 describes the respondents' household land use patterns. The table demonstrates that agriculture remains the predominant land use criterion among the respondents in 2000, 2010, and 2020, despite their decreasing trends.

Table 3. Household land use of the respondents in 2000, 2010 and 2020.

Year	Agriculture (%)	Residential (%)	Leasing purpose (%)	Industrial (%)	Unused (%)
2000	64.97	17.51	6.35	3.05	8.12
2010	49.75	25.89	14.21	6.6	3.55
2022	40.61	28.17	24.62	6.6	0.0

Table 3 also shows that land utilized for residential (housing) has steadily increased. By 2020, it had increased from approximately 17.5 percent in 2000 to over 28 percent. Residential use of the lands has increased because of increased family size.

The table describes that land leasing (renting land) to others has experienced a significant increase. A mere 6.3 percent respondent leased their lands in 2000; however, by 2020, this tendency had increased to approximately 25 percent. The respondents claimed that an increasing number of households are leasing their land, potentially due to the fact that they are no longer cultivating at home or require additional income.

Industrial/commercial utilizations of land have relatively consistent than the other land use patterns in the district, with a slight increase from 3 percent in 2000 to 6.6 percent in 2010, and no further changes anticipated by 2020.

3.4. Correlation between settlements, vegetation, croplands, and waterbodies changes in 2000, 2010, and 2020

Table 4 shows the results of Spearman's rank correlation coefficients between settlements and Vegetations, and correlation coefficients between Croplands and Waterbodies. The table displays a significant negative correlations between settlements and vegetation ($r = -0.99$) and between settlements and waterbodies ($r = -0.95$) with statistical significance ($p < 0.001$). It indicates that an increase in settlements leads to a proportionate decrease in vegetation. Likewise, increased agricultural lands (croplands) lead to significant reductions in waterbodies.

Table 4. Correlations between settlement, croplands and waterbodies changes in 2000, 2010 and 2020.

Year	Settlements (km^2)	Vegetation (km^2)	Croplands (km^2)	Waterbodies (km^2)	Spearman's rank correlation coefficients between settlements and Vegetations (r)	p-value	Spearman's rank correlation coefficients between Croplands and Waterbodies (r)	p-value
2000	81	449	595	378				
2010	187	289	714	360	−0.99	< 0.001	−0.95	< 0.001
2020	206	263	905	181				

3.5. Respondent's perceptions about the land use and land cover change

According to 208 respondents, the land use and land cover of this area have experienced significant changes. The human settlements have expanded due to the increasing family size they stated. Furthermore, the natural water passing systems, such as canals and minor rivers, have been obstructed by infrastructural developments, such as roads, embankments, and settlements. On the other hand, the reduced water flows from upstream are causing rivers and canals to dry up. In the majority of cases, the lands that are in need of turning and recuperating from rivers are being used as croplands. Additionally, agricultural lands beside the roads and other infrastructure and vegetated areas are the primarily being converted into human settlements marked by the respondents. People stated that there were a huge area barren and unutilized lands 30 to 40 years back because of sacristy of water and nature oriented agricultural land utilization patterns. But after the introduction of ground water withdrawal technologies in this area, the barren and unutilized lands have been reduced.

3.6. Respondent's perceptions about the impacts LULC change on the ecosystems

3.6.1. Impacts of LULC on the biodiversity

Table 5. Associations between ecosystem change and biodiversity loss; and the presence of foreign plant species increase and local plant species decrease.

	Biodiversity loss		**Total Frequency**	**Df**	x^2	***p*-value**
Ecosystem change	**Yes**	**No**				
Yes	208	75	283	1	173.11	< 0.001
No	0	111	111			
Total	208	186	394			
Water body decrease	**Aquatic ecosystem**		**Total Frequency**	**Df**	x^2	***p*-value**
	Significant change	**No change**				
Yes	147	112	259	1	82.09	< 0.001
No	135	0	135			
Total	282	112	394			
Presence of foreign plant species increase	**Local plant species decrease**		**Total Frequency**	**Df**	x^2	***p*-value**
	Yes	**No**				
Yes	200	96	296	1	134.47	< 0.001
No	0	98	98			
Total	200	194	394			

208 respondents claimed that the ecosystem of the locality have undergone a significant transformation over the decades. Further, people's perceptions indicate a significant association between ecosystem change and biodiversity loss. A greater proportion of respondents (208 out of 283, 73.5 percent) who perceive an ecosystem change also perceive a loss of biodiversity. The evidence of a strong chi-square value and a low p-value shown in **Table 5** indicates a significant relationship between ecosystem change and biodiversity loss. Moreover, the table also indicates a

significant association between decreasing trends of waterbodies and significant change of aquatic ecosystems ($p < 0.001$).

While asking the reasons, 89 responses were that natural ecosystem existed in this area supported by natural arrangements. However, as population increased, people began using arable lands and vegetation-covered lands for human settlement. In the croplands and vegetated areas, numerous insects flourished, and numerous bird species established their homes. Croplands were the sources of food, and trees were the shelters. As people in Nilphamari district converted lands into settlements, they also altered natural ecosystems to outfit their own preferences claimed by the respondents. Another group of 52 respondents claimed that there were a lot of natural canals, wetlands, and small rivers available in this area. However, those wetlands, canals, and rivers were the source of shelter for many fish species and source of food for bird species. As humans are blocking the water flows for their own purposes, many of those canals, wetlands, and rivers are dried up. A respondent from stakeholders' consultation answered it asking questions that *"Can a fish live without water? Can a bird catch fish in the dry lands?"* He further added that *"As water and fish is not available, I rarely saw birds like Herons, Egret, Gallinule in last 10 years. But they were seen at a certain time in a year event a decade back."*

The trends of land use change affect the ecosystems emerged from the agricultural land use. Extensive and commercial agricultural practices have been increased over the years. These changes brought excessive utilization of technological tools, pesticides and fertilizers. Traditional agricultural practices of the local farmers protected the local biological diversity considering ecological benefits, whereas modern and commercial agricultural practices like excessive utilization of fertilizers and pesticides drastically killed the biotic element of ecosystems.

3.6.2. Impacts of LULC on the local plant species

The respondent's perceptions demonstrate a significant association between increasing of foreign (non-native) plant species and a decrease in local plant species. It is indicative that increasing trends of non-native species causes a significant decrease of local (native) plant species. An increase in non-native species is perceived by the majority of respondents (200 out of 296, 67.6%), who also perceive a decrease in local species. This suggests that there is a professed threat to the biodiversity of the local territory from foreign species.

Respondents reasoned that foreign species, like eucalyptus, acacia auriculiformis, raintree, etc., have increased in huge numbers in Nilphamari district over the decades, dominating the local ones. They claimed that these foreign species, particularly eucalyptus, are not environment-friendly, posing a serious threat to natural water bodies and soil. Furthermore, it has severe effects on the bird community; for example, most native trees are bushy and suitable for building nests for birds, whereas foreign trees like eucalyptus do not provide options for the local birds. The bird species either migrated to another area or their reproductive rate has declined due to habitation loss. Nevertheless, the people are planting these trees because they generate wood for a very quick time, and they can use the wood or sell it to the market.

Not only indigenous tree species, but also some native cropping practices, have been reduced due to commercial agrarian practices. For example, this area was

historically well-known for its wheat, burley, jute and caun rice, cultivation. However, these crops are no longer cultivated in this location. Tobacco and maize cultivations replace these crops which are not local varieties.

4. Discussion

This study explored the land use changes and their impacts on the ecosystems in Nilphamari, located in the Teesta River Basin in the northwestern Bangladesh. The results of this investigation suggest that the vegetation cover and water bodies have significantly decreased from 2000 to 2020. In contrast, agricultural land use (croplands) and settlements have experienced an increase in size over the years. This study replicates the findings of prior studies (Alele and Harold, 2024; Hoque et al., 2020; Rahman and Szabo, 2021; Rahman et al., 2023) conducted in Bangladesh and beyond. However, this study represents a distinct result considering the relationship between land use changes and their implications on local ecosystems. Although prevailing literatures explored how land use changes affects the ecosystem services (Hoque et al., 2020; Hasan et al., 2020; Rahman and Szabo, 2021; Tripathi et al., 2021), they did not provide a comprehensive overview on how the changes affect ecosystems, including local biodiversity, local (native) plant species, local bird species and aquatic ecosystems. They also failed to detail and extend their findings on how increasing agricultural land use affects the local ecosystems from local people's perspectives. Consequently, this study distinctly fulfills the literature gap considering Teesta River Basin of northwestern Bangladesh. Nevertheless, this study suggests that more and more research need to be conducted to reveal the dimensions and diversity of the impacts of land use and land cover changes on local ecosystems in Bangladesh.

This study uncovered that land use changes have negative consequences on the local ecosystem in Nilphamari District. For example, extensive agricultural Land use intensified the local biodiversity loss resulted from the excessive utilization of chemical fertilizers and pesticides. It is an evident that excessive use of chemical fertilizers and pesticides has negative effects on the biological elements (Baweja et al., 2020; Sharma et al., 2019). This study finding represents a testimony on how land use changes indirectly affect local biodiversity. This study urges for governmental regulations to prevent arbitrary utilizations of pesticides and chemical fertilizers in agricultural lands to protect local biodiversity. This study emphasizes on promoting the traditionally and locally developed pest controlling mechanisms for ensuring sustainable agricultural practices.

The findings of this investigation also revealed that the waterbodies in the Nilphamari district have undergone a significant transformation in the past two decades. Therefore, the aquatic ecosystem has changed into a terrestrial ecosystem. This result is supported by other study conducted by Anzum et al. (2023). Croplands have been established on the land which was previously occupied by waterbodies. Thus, the conversion of waterbodies into terrestrial ecosystem has resulted in a decrease of the number of organisms under water. Moreover, decreasing trends of surface waterbodies accelerate peoples' (farming communities in particular) dependency on groundwater for their irrigation purpose. This study suggests for

protecting the waterbodies to preserve the water ecosystems and excessive dependency on groundwater for irrigation.

One of the important findings of this study is that Nilphamari has been observing widespread expansions of foreign tree species, including eucalyptus, replacing the local species. Information of the Bangladesh Bureau of Statistics (2011) advocates the finding of this investigation. These foreign species are not environment-friendly, posing a serious threat to natural waterbodies and soil (Daily Star, 2024). It has been well argued that non-native/foreign species cause for environmental disasters in Bangladesh (Daily Observe, 2024). Although North Bengal including Nilphamari faces severe water scarcity, people have been planting it to produce wood, either for economic benefits within a short time or for household uses (Daily Star, 2024). These practices have a negative impact on local bird species. Birds require bushy trees to be settled or for creating nests. As non-native/foreign tree species are not bushy enough to make nests, birds either migrated from this area or declined. Additionally, commercial agrarian practices have resulted in decaying of certain indigenous cropping practices, such as cultivation of wheat, burley, and caun rice. Nevertheless, the cultivation of these commodities is no longer conducted in this location. These cropping practices are replaced by the cultivation of tobacco, maize and other commercial agricultural crops. This article emphasizes on the conservation of local tree species and cropping practices. Government should include specific policy to prevent widespread use of non-native and foreign species. They should have proper and sustainable action plans for protecting the local and indigenous cropping practices.

4.1. Bangladesh land use policy: Nothing beyond the anthropocentric perspective

For governing the lands, the Government of Bangladesh (GoB) established a National Land Use Plan 2001 as a regulatory framework. This policy principally grounded on the anthropocentric perspective, referred as a philosophical viewpoint that land has value as it serves the human interests (Enger and Smith, 2015). The policy implications state that land is a fundamental requirement for human survival and sources of human use. Land use changes impacts over the livelihoods reducing water resources and arable lands. In addition, the Gross Domestic Product (GDP) and Gross National Product (GNP) are influenced by the natural environment, lands, and waterbodies. Therefore, it is necessary to integrate these three natural resources in order to ensure their appropriate utilization (National Land Use Plan, 2001). Current policy emphasizes on the protection of agricultural lands and other natural resources like waterbodies and natural settings only considering the human wellbeing and economic growth. It denies protection of the biodiversity and ecosystem diversity for the sake of nature itself.

Furthermore, Bangladesh has an extensive emphasis on attaining the Sustainable Development Goals, with a particular importance on SDG 15 (life on land). Governments' 8th 5-year (2020–2025) plan also made focusing on the Sustainable Development Goals (Bangladesh Planning Commission, 2020; MoLGED, 2020). By 2030, the country wants to have 20 percent of its territory covered by forests. Once more, Bangladesh aims to raise the percentage of freshwater body's biodiversity from

3 percent in 2018 to 5 percent by 2023 (MoP, 2020). This study identifies the prevailing and underlying challenges for attaining both country's 8th five years plans and sustainable development goals. A well-defined inclusive and non-anthropocentric land management plans and their execution could protect other forms of life on land by protecting land itself reforming the existing policy. Policy must ensure the natural settings of the lands for their own sake rather thinking the human interests.

4.2. Future implications of land use change in Nilphamari

Nilphamari is an agriculturally famous district of Northwestern Bangladesh (in the Teesta River Basin) (MoLGED, 2024). A few decades back, the agriculture was nature oriented and surface water was the source of irrigation in the district. As surface water sources have significantly decreased, people stated using groundwater using pumps (Although there is a government intervened irrigation project existed in the district called "Teesta Barrage Irrigation Project" to supply surface water for croplands, it does not provide sufficient water to the farmers throughout the district). As agricultural lands have increased in the district over the decades, it has been putting an increasing pressure on the groundwater.

Again, Northwestern region of the country, specifically Nilphamari district is vulnerable to severe drought (Murad and Islam, 2011). A historical data shows that between 1951 and 2006, Bangladesh has experienced at least 10 severe droughts and every time Nilphamari district was identified in the list of severely affected district (Selvaraju et al., 2006). Moreover, during dry seasons, the district suffers a severe water crisis for irrigations (Raihan et al., 2017). Both water shortages for irrigation and drought effects are getting deepened by the limited water body. That's why, Nilphamari district is in the process of desertification (Alam et al., 2021). The projection of desertification may turn into reality if the water bodies drastically reduced in this district at its current rate. Moreover, there might be a possibility of lowering the groundwater in the district because of excessive dependence on groundwater for agricultural irrigation purposes. A well-thought master plan is an urgent need to protect water body to reduce agricultural water stress and minimize the effects of droughts.

5. Conclusions

The results of the study showed that waterbodies and vegetation coverage in Nilphamari district have significantly reduced in the last 20 years whereas croplands (agricultural lands) and settlement are in increasing trends. The field data further revealed that waterbodies and vegeted areas have transferred into terrestrial lands and have been utilized either as for settlement or agricultural purposes. Agricultural land use subsequently affects the biological elements of the ecosystems due to excessive utilization of pesticides and chemical fertilizers. The transformations in land utilization patterns in Nilphamari district have negative consequences on the local ecosystems. Such as, according to the study findings, there is a significant negative association between ecosystem changes and biodiversity losses, and waterbody decrease and aquatic ecosystem changes. Land use changes in the district also changes the plant species. Non-native/ foreign tree species have been taking the place of native

species because of its economic benefits despite having negative environmental consequences. Current findings represent a real challenge for achieving the sustainable development goal 15 within 2030 and the 8th 5-year plan of the GoB considering increasing forest areas and fresh waterbodies. In this context, government should have well-specified land use policies for conserving the waterbodies considering the local aspects for protecting ecosystems and biodiversity. Furthermore, proper regulations and specific guidelines on pesticide and chemical fertilizer use in the croplands should be a priority to preserve the ecosystems and biodiversity in the cropland ecosystems. This study suggests that government should apply and emphasizes traditional and indigenous pest-controlling mechanism for the welfare of the ecosystems. For preserving the native species and traditional cropping practices, government should strictly handle non-native (plant) species and non-native seed. In conclusion, this study emphasizes on the considering a non-anthropocentric and inclusive policy implications considering the welfare of other communities in the ecosystems rather than humans.

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